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# Butterfly diversity in Kolkata metropolis: a synoptic check list

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**Abstract:** Butterflies are considered charismatic species for conservation planning as well as environmental monitoring and management. In this study, we assessed the richness of butterfly and associated plant species in Kolkata, India to provide baseline information on the extent of species diversity and prospective use in urban planning and conservation. In association with 39 different herbs and shrubs, at least 54 species of butterflies, belonging to five families, were found in urban habitats of Kolkata. Variations in the diversity indices of the butterfly and plant were observed over the months with highest values in the summer and postmonsoon period and low in the winter months. Butterfly association with the host plants reflected the ascendancy of generalist species in the study area. The network of butterfly and the host plant may be explored further to facilitate the conservation of butterfly and sustain the environmental quality of Kolkata, India

**Key words:** Lepidoptera, species diversity, conservation

## INTRODUCTION

The relevance of monitoring biological diversity can be linked with appraisal of changes in the environmental quality at the local and regional scales. Evaluation of species diversity is a pre requisite component for habitat management and prediction of the environmental impacts on the biota (Niemelä 2000; Yoccoz et al. 2001; Nichols and Williams 2006). Assessment of taxa specific diversity enables evaluation of the ecosystem processes and ecosystem services with higher precision (Díaz et al. 2006). Diversity analysis often focuses on the single taxon instead of the species assemblage to predict the ecosystem functions and the services derived from the specific taxa. Selection of limited taxa is often preferred over whole community due to resource limitation (Mihindukulasooriya et al. 2014) and in certain instances the presence/absence data provide useful estimation of population size (Williams et al. 2002; Koleff et al. 2003; MacKenzie 2005). The target taxon varies with the quality of the landscapes and the purpose of the study. Insects are one of the preferred taxa for evaluation of biodiversity for biological conservation, and retrieving information about the environmental conditions (Kim 1993; Samways 1994; Simonson et al. 2001). The taxonomic distinctness and the variations in the habitats exploited by different forms of insects in both terrestrial and aquatic habitats forms a strong basis for using insects as target taxa for monitoring the species diversity. The changes in the environmental quality are easily retrieved through the corresponding changes in the diversity of certain taxa, which are recognized as indicator species, utilized for environmental monitoring (Hogsden and Hutchinson 2004). For terrestrial ecosystems, butterflies are considered as indicator species providing vital information about the environmental conditions. Butterflies are linked with different ecosystem services that are essential for sustenance of the environmental quality and integrity (Kumar 2013). The interaction between diverse species of butterflies and plants are well studied group of mutualist, which is why the representation of the diversity of butterflies is connected with almost equivalent group of plants in any area.

On a global scale more than 19,000 species of butterflies have been described (Heppner 1998), of which around 1,500 species are recorded from India (Haribal 1992). Among the different areas of India, butterfly diversity has been elaborated in many studies including the interactions between different plant species of the concerned area (Kunte et al. 1999). The record of the butterflies associated with the native and the indigenous plants are long being a focus in Kolkata, India (Dronamraju 1958, 1960), which prompted us to carry out field investigation and record the richness and abundance of the butterflies. In order to enhance the environmental monitoring of the concerned geographical area, systematic investigation

on the butterfly richness and the related plant species is essential. The results of the study are presented in this narrative to document a synoptic view of the butterflies recorded from the urban areas of Kolkata, India. An account of the species richness and abundance of butterflies and the related plants species is expected to benefit environmental monitoring and preservation of the species for sustaining ecosystem services.

## MATERIALS AND METHODS

This study was carried out in Kolkata, West Bengal, India, between January 2013 and December 2013. We randomly selected three study sites: vicinity of Dumdum metro station (22°37′16.69″ N, 088°23′34.26″ E), Nalban (22°34′08.92″ N, 088°25′10.82″ E), and vicinity of Ballygunge Phari (22°31′41.56″ N, 088°21′57.56″ E). A Global Positioning System receiver (Garmin GPSMAP® 76Cx) was used to record the geographic coordinates of each site. Each site was visited twice in a month. On each occasion, we observed butterflies on either side of a 2.5 m transect using the 'Pollard Walk' method (Pollard 1977; Pollard and Yates 1993) with necessary modifications related to the sampling units considered in the present study. The butterflies were identified in the field using illustrated guides (Wynter-Blyth 1957; Haribal 1992; Kunte 2000; Kehimkar 2008). Occasionally they were captured by hand net for identification, then released. The abundance of each butterfly species was also recorded. We also recorded plant species along each of the transects, following the method employed by Clark et al. (2007), that is, plant species within 2.5 m of each side of each transect were recorded. We recorded those species that are mainly food plants of butterflies and ignored trees except one species (*Carica papaya* L). We collected flowering plant specimens and preserved them for identification by preparing herbarium. Plants were identified to family and species using keys (Kehimkar 2000; Paria 2005, 2010; Mandal and Jana 2012). Using Biodiversity Pro software (McAleece et al. 1997) the diversity indices of the butterfly abundance were calculated. Species diversity was calculated using Shannon diversity index [$(H' = \sum P_i \ln p_i)$ and Shannon $H_{max}$ ($H_{max}= Log_{10}(S)$)], Shannon evenness was calculated using the formula; $J = H'/H_{max}$, where, $H'$ = information content of sample (bits/individual) or Shannon diversity index, and $P_i$ = proportion of total sample belonging to $i^{th}$ species, S = total number of species in habitat (species richness) (Magurran 2004).

## RESULTS

We recorded 54 butterfly species belonging to five families (Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Hesperiidae; Table 1; Figure 1) and 39 species of nectar plants, along with flowering time and plant type, over the duration of the study period (Table 2).

**Table 1.** List of butterflies recorded from Kolkata, India during January 2013 to December 2013

| Common Name | Scientific name | Short form |
|---|---|---|
| **Family Papilionidae** | | |
| Common jay | *Graphium doson* (Felder & Felder, 1864) | GDO |
| Tailed Jay | *Graphium agamemnon* (Linnaeus, 1758) | GAG |
| Common Mormon | *Papilio polytes* (Linnaeus, 1758) | PPO |
| Lime Butterfly | *Papilio demoleus* (Linnaeus, 1758) | PDE |
| Common Mime | *Chilasa clytia* (Linnaeus, 1758) | CCL |
| Common Rose | *Pachliopta aristolochiae* (Fabricius, 1775) | PAR |
| **Family Pieridae** | | |
| Three-spot Grass Yellow | *Eurema blanda* (Boisduval, 1836) | EBL |
| Common Grass Yellow | *Eurema hecabe* (Linnaeus, 1758) | EHE |
| Common Emigrant | *Catopsilia pomona* (Fabricius, 1775) | CPO |
| Mottled Emigrant | *Catopsilia pyranthe* (Linnaeus, 1758) | CPY |
| Common Wanderer | *Pareronia valeria* (Cramer, 1776) | PVA |
| Striped Albatross | *Appias libythea* (Fabricius, 1775) | ALI |
| Common Gull | *Cepora nerissa* (Fabricius, 1775) | CNE |
| Common Jezebel | *Delias eucharis* (Drury, 1773) | DEU |
| Psyche | *Leptosia nina* (Fabricius, 1793) | LNI |
| **Family Nymphalidae** | | |
| Blue Tiger | *Tirumala limniace* (Cramer, 1775) | TLI |
| Striped Tiger | *Danaus genutia* (Cramer, 1779) | DGE |
| Plain Tiger | *Danaus chrysippus* (Linnaeus,1758) | DCH |
| Common Crow | *Euploea core* (Cramer, 1780) | ECO |
| Common Evening Brown | *Melanitis leda* (Linnaeus, 1758) | MLE |
| Common Palmfly | *Elymnias hypermnestra* (Linnaeus, 1763) | EHY |
| Common Bushbrown | *Mycalesis perseus* (Fabricius, 1775) | MPE |
| Common Five-ring | *Ypthima baldus* (Fabricius, 1775) | YBA |
| Common Four-ring | *Ypthima huebneri* (Kirby, 1871) | YHU |
| Tawny Coster | *Acraea violae* (Fabricius, 1775) | AVI |
| Common Leopard | *Phalanta phalantha* (Drury, 1773) | PPH |
| Chestnut-streaked Sailor | *Neptis jumbah* (Moore, 1857) | NJU |
| Angled Castor | *Ariadne ariadne* (Linnaeus, 1763) | AAR |
| Common Castor | *Ariadne merione* (Cramer, 1779) | AME |
| Peacock Pansy | *Junonia almana* (Linnaeus, 1758) | JAL |
| Grey Pansy | *Junonia atlites* (Linnaeus, 1763) | JAT |
| Lemon Pansy | *Junonia lemonias* (Linnaeus, 1758) | JLE |
| Great Eggfly | *Hypolimnas bolina* (Linnaeus, 1758) | HBO |
| **Family Lycaenidae** | | |
| Indian Sunbeam | *Curetis thetis* (Drury, 1773) | CTH |
| Slate Flash | *Rapala manea* (Hewitson, 1863) | RMA |
| Common Silverline | *Spindasis vulcanus* (Fabricius, 1775) | SVU |
| Common Ciliate Blue | *Anthene emolus* (Godart, 1824) | AEM |
| Common Pierrot | *Castalius rosimon* (Fabricius, 1775) | CRO |
| Red Pierrot | *Talicada nyseus* (Guérin-Méneville, 1843) | TNY |
| Striped Pierrot | *Tarucus nara* (Kollar, 1848) | TNA |
| Zebra Blue | *Tarucus plinius* (Fabricius, 1793) | TPL |
| Tiny Grass Blue | *Zizula hylax* (Fabricius, 1775) | ZHY |
| Pale Grass Blue | *Pseudozizeeria maha* (Kollar, 1844) | PMA |
| Dark Grass Blue | *Zizeeria karsandra* (Moore, 1865) | ZKA |
| Quaker | *Neopithecops zalmora* (Butler, 1870) | NZA |
| Plains Cupid | *Catochrysops vapanda* (Semper, 1890) | CVA |
| **Family Hesperiidae** | | |
| Brown Awl | *Badamia exclamationis* (Fabricius, 1775) | BEX |
| Common Banded Awl | *Hasora chromus* (Cramer, 1780) | HCH |
| Indian Skipper | *Spialia galba* (Fabricius, 1793) | SGA |
| Straight Swift | *Parnara guttatus* (Bremer & Gray, 1853) | PGU |
| Rice Swift | *Borbo cinnara* (Wallace, 1866) | BCI |
| Small Banded Swift | *Pelopidas mathias* (Fabricius,1798) | PMAT |
| Large Branded Swift | *Pelopidas subochracea* (Moore, 1878) | PSU |
| Indian Palm Bob | *Suastus gremius* (Fabricius, 1798) | SGR |

**Figure 1**. Butterfly species recorded in Kolkata, India. 1) *Graphium doson*, 2) *Graphium agamemnon*, 3) *Papilio polytes*, 4) *Papilio demoleus*, 5) *Chilasa clytia*, 6) *Pachliopta aristolochiae*, 7) *Eurema blanda*, 8) *Eurema hecabe*, 9) *Catopsilia pomona*, 10) *Catopsilia pyranthe*, 11) *Pareronia valeria*, 12) *Appias libythea*, 13) *Cepora nerissa*, 14) *Delias eucharis*, 15) *Leptosia nina*, 16) *Tirumala limniace*, 17) *Danaus genutia*, 18) *Danaus chrysippus*. 19) *Euploea core*, 20) *Melanitis leda*, 21) *Elymnias hypermnestra*, 22) *Mycalesis perseus*, 23) *Ypthima baldus*, 24) *Ypthima huebneri*, 25) *Acraea violae*, 26) *Phalanta phalantha*, 27) *Neptis jumbah*, 28) *Ariadne ariadne*, 29) *Ariadne merione*, 30) *Junonia almana*, 31) *Junonia atlites*, 32) *Junonia lemonias*, 33) *Hypolimnas bolina*, 34) *Curetis thetis*, 35) *Rapala manea*, 36) *Spindasis vulcanus*, 37) *Anthene emolus*, 38) *Castalius rosimon*, 39) *Talicada nyseus*, 40) *Tarucus nara*, 41) *Tarucus plinius*, 42) *Zizula hylax*, 43) *Pseudozizeeria maha*, 44) *Zizeeria karsandra*, 45) *Neopithecops zalmora*, 46) *Catochrysops vapanda*, 47) *Badamia exclamationis*, 48) *Hasora chromus*, 49) *Spialia galba*, 50) *Parnara guttatus*, 51) *Borbo cinnara*, 52) *Pelopidas mathias*, 53) *Pelopidas subochracea*, 54) *Suastus gremius*.

**Table 2.** List of plants observed during January 2013 to December 2013 irrespective of study sites. Type: S = Shrub, H = Herb, T = Tree.

| Species code | Scientific name | Type | Flower colour | Flowering time |
|---|---|---|---|---|
| | **Family Acanthaceae** | | | |
| AA | *Adhatoda vasica* Nees | S | White to red to violet | April to October |
| | **Family Amaranthaceae** | | | |
| AB | *Alternanthera sessilis* (L.) R.Br. ex DC. | H | White | January to December |
| AC | *Gomphrena celosioides* Mart. | H | White | December to May |
| | **Family Apocynaceae** | | | |
| AD | *Catharanthus roseus* (L.) G. Don | S | Pink/white | January to December |
| | **Family Asclepiadaceae** | | | |
| AE | *Calotropis gigantea* (L.) W. T. Aiton | S | Violet | January to August |
| | **Family Asteraceae** | | | |
| AF | *Pluchea indica* (L.) Less. | S | Pinkish | February to May |
| AG | *Ageratum conyzoides* L. | H | Pale blue | January to December |
| AH | *Eclipta alba* (L.) Hassk. | H | White | January to December |
| AI | *Mikania cordata* (Burm.f.) B.L.Rob. | H | White | October to March |
| AJ | *Spilanthes acmella* (L.) Murray | H | Yellow | November April |
| AK | *Tridax procumbens* L. | H | Yellow | January to December |
| AL | *Vernonia cinerea* (L.) Less | H | Pink | January to December |
| AM | *Parthenium hysterophorus* L | H | White | January to December |
| | **Family Boraginaceae** | | | |
| AN | *Heliotropium indicum* L. | H | Violet | January to December |
| | **Family Capparaceae** | | | |
| AO | *Capparis zeylanica* L. | S | Violet | January to Junuary |
| | **Family Cleomaceae** | | | |
| AP | *Cleome rutidosperma* DC. | H | Violet | August to January |
| AQ | *Cleome viscosa* L. | H | Yellow | April to August |
| | **Family Commelinaceae** | | | |
| AR | *Commelina benghalensis* L. | H | Blue | August to December |
| AS | *Commelina salicifolia* Thwaites, nom. illeg. | H | Blue | January to August |
| | **Family Cyperaceae** | | | |
| AT | *Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel | H | White | July to January |
| | **Family Euphorbiaceae** | | | |
| AU | *Jatropha gossypifolia* L. | S | Red | January to July |
| AV | *Jatropha curcas* L. | S | Yellow | April to October |
| AW | *Croton bonplandianum* Baill | H | White | May to December |
| | **Family Fabaceae** | | | |
| AX | *Crotalaria pallida* Aiton | H | Yellow | January to July |
| | **Family Flacourtiaceae** | | | |
| AY | *Flacourtia indica* (Burm. fil.) Merr. | S | Yellow | January to Jun |
| | **Family Lamiaceae** | | | |
| AZ | *Leucas aspera* (Willd.) Link | H | White | February toJuly |
| | **Family Linderniaceae** | | | |
| BA | *Vandellia crustacea* (L.) Benth. | H | white | June toNovember |
| | **Family Malvaceae** | | | |
| BB | *Abutilon indicum* G.Don | S | Yellow | September to April |
| BC | *Sida acuta* Burm. fil. | S | Yellow | June to December |
| BD | *Sida rhombifolia* L. | S | Yellow | January to December |
| | **Family Oxalidaceae** | | | |
| BE | *Oxalis corniculata* L. | H | Yellow | May to June |
| | **Family Passifloraceae** | | | |
| BF | *Passiflora foetida* L | H | Violet | May to December |
| | **Family Rhamnaceae** | | | |
| BG | Ziziphus mauritiana Lam. | S | Yellow | August to December |
| | **Family Rubiaceae** | | | |
| BH | *Ixora coccinea* L | S | Red, yellow or pink | January to December |
| | **Family Caricaceae** | | | |
| BI | Carica papaya L | T | White | April to Jun |
| | **Family Rutaceae** | | | |
| BJ | *Glycosmis pentaphylla* (Retz.) Correa | S | Pinkish | January to December |
| | **Family Solanaceae** | | | |
| BK | *Cestrum diurnum* L. | S | White | October to June |
| | **Family Verbenaceae** | | | |
| BL | *Clerodendrum viscosum* vent | S | White | December to March |
| BM | *Lantana camara* L. | S | Yellow | January to December |

Nymphalidae presented the highest richness with 18 species recorded (33.33%), followed by Lycaenidae with 13 species (24.07%), Pieridae with nine species (16.67%), Hesperiidae with eight species (14.81%) and Papilionidae with six species (11.11%). Among plant species, 21 species were herbs, 17 species were shrubs. The species diversity and evenness were expressed by values of Shannon H′, Shannon $H_{max}$, and Shannon J′ indices (Figure 2), which followed a similar pattern, while the monthly variations were clear. The matrix of butterfly

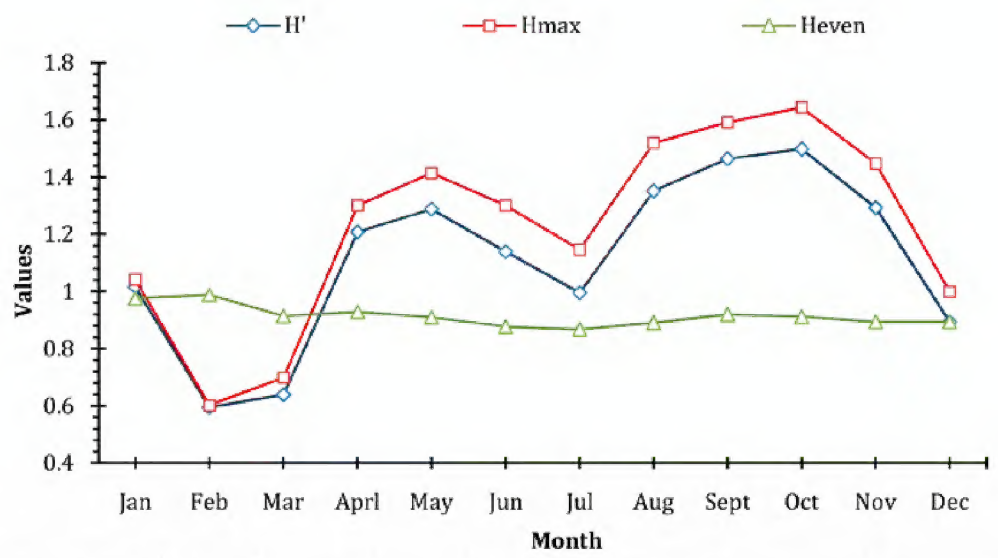


**Figure 2.** The values of the diversity indices (Shannon-Wiener) of butterflies by month throughout the year (2013) in Kolkata, India.

and the linked flowering plants are represented in Table 3, which indicates a wide range of plant preferences by butterflies such as *Catopsilia pomona*, *Eurema hecabe*, *Catopsilia pyranthe*, *Eurema blanda*, *Zizula hylax*, *Pseudozizeeria maha*, *Papilio polytes*, *Papilio demoleus*. The pattern of abundance of different butterflies indicated that the most abundant butterfly species was *Catopsilia pomona* and the least abundant species was *Tarucus plinius* (Figure 3).

## DISCUSSION

The butterfly species richness observed in our study is comparable to other urban areas of India (Kunte 2000; Agarwala et al. 2010; Sarma et al. 2012; Arya et al. 2014; Kumar 2014), including Kolkata. Although the butterfly species recorded in this study is consistent with earlier studies (Chowdhury and Soren 2011; Nair et al. 2014), variations in the total species richness is evident, possibly because of the differences in the size of the sampling area (Nair et al. 2014) or the habitats conditions within the sampling area. Compared to the earlier studies, the sample size and area was greater in the present study, though the variations in the microhabitat conditions were limited. Earlier studies included the areas in the vicinity of the wetlands (Chowdhury and Soren 2011) as well as suburban conditions where the butterfly richness is generally high, particularly in the adjacent regions of Kolkata, India (Mukherjee et al. 2015). Thus variations in the sampling areas (Chowdhury and Soren 2011) and

**Table 3.** Matrix of butterfly and plant species associations observed in Kolkata, India. Butterfly species are represented by their 'short form' (see Table 2) The '+ sign' indicates butterfly/plant association.

| Butterfly species | Nectar plant species | | |

**Table 3.** *Continued.*

| Butterfly species | Nectar plant species | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AA | AB | AC | AD | AE | AF | AG | AH | AI | AJ | AK | AL | AM | AN | AO | AP | AQ | AR | AS | AT | AU | AV | AW | AX | AY | AZ | BA | BB | BC | BD | BE | BF | BG | BH | BI | BJ | BK | BL | BM |
| TLI | | | | | | + | + | | + | | | + | | + | | | + | | | | + | + | | + | + | | | | | | | | + | | | + | + | + |
| DGE | | | | | | + | + | | + | | | + | | + | | | + | | | | + | + | | + | + | | | | | | | | + | | | | + | + | + |
| DCH | | | | | + | + | + | | + | | + | + | | + | | | | | | | + | + | | + | + | | | | | | | | + | | | | + | + | + |
| ECO | | | | | | + | + | | + | | | + | | + | | | | | | | | | | + | + | | | | | | | | + | | | | | | |
| MLE | | | | | | | | | | | | + | | | | | | | + | | | | | | | | | | | | | | | | | | | | |
| EHY | | | | | | | | | | | | + | | | | | | + | | | + | | | | | | | | | | | | | | | | | | |
| MPE | | | | | | | | | | | | | | | | | | | + | | + | | | | | | | | | | | | | | | | | | |
| YBA | | | | | | | | | | | | | | | | | + | | | | | | | | | | | | | | | | + | | | | | | |
| YHU | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + | | | | + | | |
| AVI | | | | | | + | + | | + | | | + | | | | | | | | | | | | | + | | | | + | | | + | | | | + | + | |
| PPH | | | | | | + | + | | + | | | + | | | | | + | | | | | + | | | + | | | | + | | | + | | | | + | + | |
| NJU | | | | | | + | + | | + | | | + | | | | | + | | | | | + | | | | | | | + | | | + | | | | + | + | |
| AAR | | | | | | + | + | | + | | | + | | | | | + | | | | | + | | | + | | | | + | | | + | | | | + | + | |
| AME | | | | + | | + | + | | + | | | + | | | | | + | | | | | + | | | + | | | | + | | | + | | | | + | + | |
| JAL | | | | + | | + | + | | + | | | + | | | | | + | | | | | + | | | + | + | | | + | | | + | | | | + | + | |
| JAT | | | | | | + | + | | + | | | + | | | | | + | | | | | + | | | + | + | | | + | | | + | | | | + | + | |
| JLE | | | | | | + | + | | + | | | + | | | | | | | | | | + | | | + | | | | + | | | + | | | | + | + | |
| HBO | | | | | | + | + | | + | | | + | | | | | | | | | | + | | | + | | | | + | | | + | | | | + | + | |
| CTH | | | | | | | | | + | | | + | | | | | | | | | | + | | | | | | | + | | | | | | | | + | + | |
| RMA | | | | | | + | + | | + | | | | | | | | | | | | | + | | | | | | | + | | | | | | | + | | + | + |
| SVU | | | | | | | | | | | + | | | | | | + | | | | | | | + | | | | | + | | | | | | | + | | + | |
| AEM | | | + | | | | + | | + | | | | | | | | + | + | | | | | | + | + | | | | + | | | | | | | + | | + | |
| CRO | | | + | | + | + | | + | | | | | | | | | + | + | | | | | | + | + | | | | + | | | | | | | + | | + | |
| TNY | | | | | | | + | + | + | | + | | | | | | + | + | | | | | | + | + | | | + | + | | | | | | | + | | + | |
| TNA | | + | | | | | | + | | + | + | | | | | | + | + | + | | | | | + | + | | | + | + | | | | | | | + | | + | |
| TPL | | + | + | | | | | + | | + | + | | | + | | | + | + | + | + | + | + | | + | + | | | + | + | | | | | | | + | | + | |
| ZHY | | + | + | | + | | + | + | + | + | + | | | + | | | + | + | + | + | + | + | | + | + | | | + | + | | | | | | | + | | + | |
| PMA | | + | + | | | | + | + | | + | + | | | + | | | + | + | + | + | + | + | | + | + | + | | + | + | | | | | | | + | | + | |
| ZKA | | + | | | + | | | + | | + | + | | | + | | | + | + | + | + | + | + | | + | + | | | + | + | | | | | | | + | | + | |
| NZA | | + | | | | | + | + | | + | + | | | | | | + | | + | + | + | + | | + | + | | | + | + | | | | | | | + | | + | |
| CVA | | + | + | | | | | + | | + | + | | | | | | + | | | | | + | | + | | | | | + | | | | | | | + | | + | |
| BEX | + | | | | | + | | | | + | | | | | | | | | | | | | | | | + | | | | | | | | | | | | + | |
| HCH | + | | | | | + | | | | + | | | | | | | + | | | | | | | | | + | | | | | | | + | | | | | + | |
| SGA | + | + | + | | | + | + | + | | + | + | | | | | | | | | | | | | | | + | | | | | | | | | | | | + | |
| PGU | + | | | + | | | + | + | + | + | + | | | | | | + | | | | | | | | | + | | | | | | | + | | | | | + | |
| BCI | + | | + | + | | + | | + | + | + | | | | | | | | | | | | | | | | + | | | | | | | + | | | | | + | |
| PMAT | + | | + | + | | + | + | + | + | + | + | + | | | | | + | | | | | | | | | + | | | | | | | + | | | | + | + | |
| PSU | + | | + | + | | + | | + | | + | | | | | | | | | | | | | | | | + | | | | | | | | | | | | | + | |
| SGR | + | | | | | | | | | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + | |

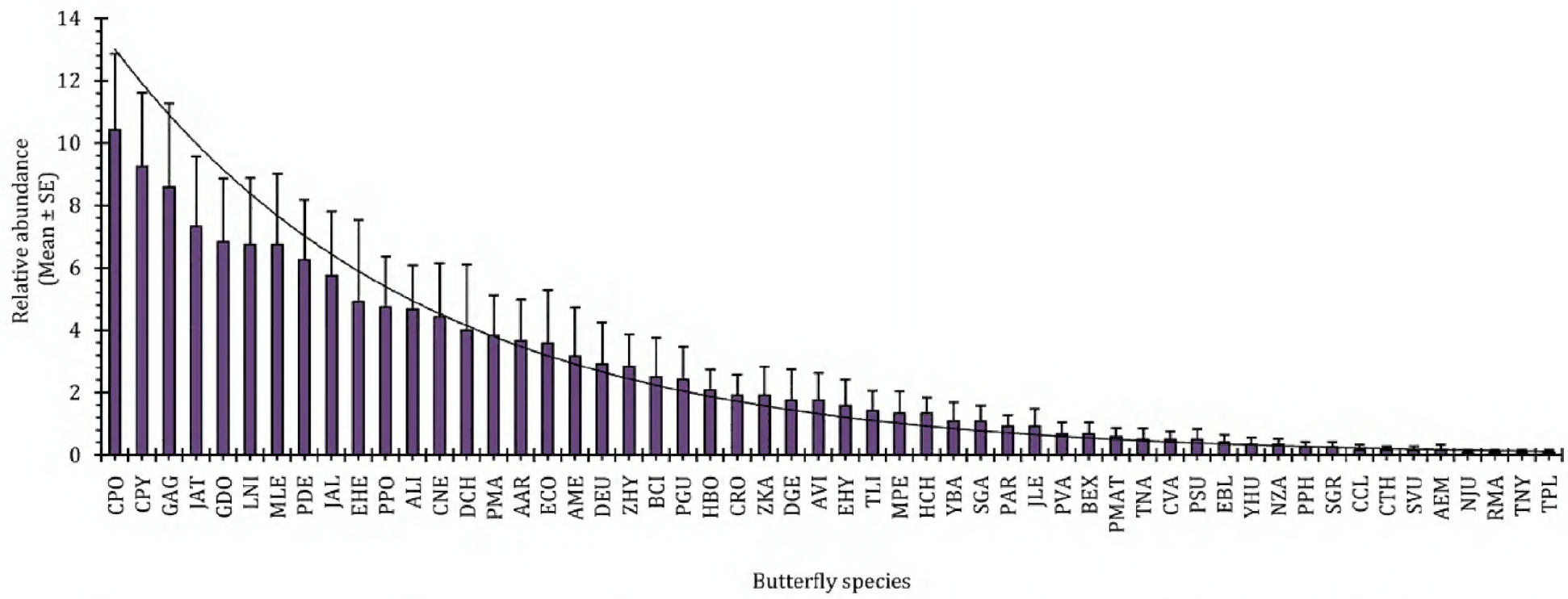
Relative abundance
(Mean ± SE)
0
2
4
6
8
10
12
14
CPO CPY GAG JAT GDO LNI MLE PDE JAL EHE PPO ALI CNE DCH PMA AAR ECO AME DEU ZHY BCI PGU HBO CRO ZKA DGE AVI EHY TLI MPE HCH YBA SGA PAR JLE PVA BEX PMAT TNA CVA PSU EBL YHU NZA PPH SGR CCL CTH SVU AEM NJU RMA TNY TPL
Butterfly species

**Figure 3.** The relative abundance of butterfly species in Kolkata, India, encountered during January 2013 to December 2013. Data of the individual transect of each month were included in construction of the relative abundance of the individual species.

the sample sizes (Nair et al. 2014) may be the reasons for the observed differences in the number of butterfly species encountered in Kolkata, India. However, the species described in the present context is similar and includes the species encountered in the earlier studies (Chowdhury and Soren 2011; Nair et al. 2014).

Among butterflies observed, Nymphalidae exhibited highest richness of butterfly species, which well corroborates with studies elsewhere in India (Tiple and Khurad 2009; Chowdhury and Soren 2011; Kumar and Mattu 2014; Nair et al. 2014). At Simla (Thakur and Bhardwaj 2011), Ankleshwar, Gujarat (Kumar 2013), and Kumaun Himalayas, Uttarakhand Arya et al. (2014), Pieridae was the dominant family. In our study, the two most abundant species (*Catopsilia pomona* and *Catopsilia pyranthe*) were also members of Pieridae. Similar to earlier studies (Wynter-Blyth 1957; Padhey et al. 2006), the maximum appearance of butterflies was in March and April (the summer season), followed by a second peak in October (post-monsoon).

The abundance of butterflies is linked to climatic conditions (Bhusal and Khanal 2008) and availability of host plants (Gutierrez and Mendez, 1995; Öckinger et al. 2009; Nimbalkar et al. 2011). Consistent to this view, in this study, plants known to support butterflies dominated the bush habitats. For instance, the numerical abundance and the association of butterflies were observed to be high for *Lantana camara, Ageratum conyzoides, Pluchea indica, Mikania cordata, Sida rhombifolia, Ziziphus mauritiana, Glycosmis pentaphylla,* and *Clerodendrum viscosum*. Although the phenology of these plants differ considerably, the perennial flowering pattern of *Lantana camara* and *Tridax procumbens* possibly accounted for the maximum load of butterfly species, consistent with earlier observations (Nimbalkar et al. 2011). Herbaceous plants such as *Mikania cordata, Cleome rutidosperma, Cleome viscosa, Ageratum conyzoides* were also found to be positive for the butterfly load at different times of the year. The species specific links of the butterfly and the host plants can be considered as a useful parameter for conservation planning of the butterfly in the urban ecosystem of Kolkata, India. Although at a proximate level, the relative abundance of different species can be considered as a basis to scale the assemblage pattern of butterflies (Figure 3), but for population enhancement, availability of the preferred plant species is equally important. Thus the conservation of the butterfly in the areas should also incorporate strategies to enhance availability of host plants using the network of butterfly and plant links observed in the present study (Table 3).

Butterflies are recognized as charismatic species that perform multiple roles in ecosystems. They can provide useful information on environmental conditions and can be used for environmental monitoring and assessment of habitats. Conservation of butterflies is relevant in the context of urban planning and management where the aesthetic values of the dwindling green spaces may be secured through the availability of the different species of butterflies. The mutualistic relationship of butterfly and plants will also benefit the sustenance of the both the groups and the environmental quality in the long run. In Kolkata, urban forests and gardens are limited, but the diverse butterfly fauna appears to be comparable to similar urban areas of India (Roy et al. 2012; Harsh 2014; Saikia 2014) and other South east Asian countries (Koh and Sodhi 2004; Sodhi et al. 2010). Thus, maintenance of gardens, green spaces and nectar plants should be prioritized for conservation of butterfly diversity while sustaining the valuable ecosystem services.

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